

CLAIMS

1. A method for repairing a defect in a photolithography mask including a transparent substrate and a pattern of opaque material, the defect being an absence of opaque material on an area that should be covered by an opaque material, the method comprising:

scanning a beam of metallic ions over the defect area to implant metallic atoms into the defect area, the metal atoms reducing the transparency of the defect area without depositing an opaque material to cover the defect area.

2. The method of claim 1 further comprising scanning a beam of metallic ions over a non-defective area of the transparent substrate near the defect to implant metallic atoms in the non-defective area, the implantation of the metallic atoms in the non-defective area causing the aerial image of the repaired mask to more closely resemble the aerial image of a non-defective mask.

3. The method of claim 1 further comprising thinning an area of the substrate to alter the phase of transmitted light.

4. A method for repairing a defect in a photolithography mask including a transparent substrate and a pattern of material, a first area around the defect characterized by a design aerial image, the defect being an absence of material on a second area that should be covered by a material or the presence of material on the second area that should not be covered by the material, the method comprising:

scanning a beam of ions over a third area to implant atoms into the third area, the atoms altering the third area and causing an actual repaired aerial image of the first area to approximate the design aerial image more closely than did an actual unrepaired aerial image.

5. The method of claim 4 in which the defect comprises a clear defect in a binary mask and in which scanning a beam of ions over a third area to implant atoms into the third area includes scanning a beam of metallic ions over the third area to implant metallic atoms into the third area to reduce its transparency.

6. The method of claim 5 in which scanning a beam of metallic ions over the third area to implant metallic atoms into the third area to reduce its transparency includes scanning a beam of metallic ions over a defect area and a non-defect area to implant metallic atoms into the defect area and a non-defect area to reduce transparency.

7. The method of claim 6 in which scanning a beam of metallic ions over a defect area and a non-defect area to implant metallic atoms into the defect area and a non-defect area to reduce its transparency includes scanning a beam of metallic ions over a defect area and a non-defect area to implant metallic atoms into the defect area and a non-defect area adjacent the defect area to reduce transparency.

8. The method of claim 4 in which the defect comprises a clear defect in a phase shift mask and in which scanning a beam of ions over a third area to implant atoms into the third area includes scanning a beam of metallic ions over the third area to reduce its thickness to alter the phase of transmitted light and to implant metallic atoms into the third area to reduce its transparency.

9. A method for repairing a defect in a photolithography mask, comprising:

locating a defect on a mask;

characterizing the defect;

determining an intended aerial image corresponding to an area of the mask that includes the defect;

determining an alternate structure that will provide an aerial image similar to the intended aerial image; and

effecting the alternate structure on the mask.

10. The method of claim 9 in which determining an alternate structure that will provide an aerial image similar to the intended aerial image includes determining an alternate structure that includes an area of metallic atoms implanted by an ion beam.

11. The method of claim 10 in which the area of metallic atoms implanted by an ion beam includes an area of an opaque defect.

12. The method of claim 11 in which the area of metallic atoms implanted by an ion beam further includes a non-defective area.

13. A method for repairing a photolithography mask including a pattern on a substrate, the mask having a defect such that the actual pattern on the mask is different from an intended design pattern, comprising:

using a laser to remove an area of the pattern including the defect;

using one or more charged particle beams to recreate in the area a pattern that provides approximately the aerial image as the intended design pattern in the area.

14. The method of claim 13 in which using one or more charged particle beams to recreate in the area a pattern that provides approximately the aerial image as the intended design pattern in the area includes using an ion beam to implant atoms to alter the transparency of a portion of the mask.

15. The method of claim 13 in which using one or more charged particle beams to recreate in the area a pattern that provides approximately the aerial image as the intended design pattern in the area includes using an ion beam to deposit ions to alter the transparency of a

portion of the mask includes using a charged particle beam to etch a portion of the mask to alter the phase of transmitted light.

16. A method for repairing a defect in a photolithography mask, comprising
measuring a defect in three dimensions by forming at least two images using charged particle beams at different incident angles; and
using the three dimensional information to program a charged particle beam system to etch the defect.

17. A method for repairing a defect in a photolithography mask, comprising:
providing a sacrificial layer of quartz on the mask substrate;
directing an ion beam toward the mask to repair a defect by depositing material or removing excess material, at least some of the ions implanting into the sacrificial layer as implanted atoms and reducing the transparency of the mask substrate; and
removing the sacrificial layer, thereby removing the implanted atoms and increasing the transparency of the mask substrate.

18. The method of claim 17 in which removing the sacrificial layer includes directing a broad ion beam at the mask to etch away the sacrificial layer.

19. A method for repairing a clear defect in a phase shift photolithography mask, comprising:
supplying a quartz-producing precursor gas to the defect area; and
directing an electron beam toward a defect area, the quartz-producing precursor gas decomposing in the presence of the electron to deposit quartz onto the defect area.

20. The method of claim 19 in which supplying a quartz-producing precursor gas to the defect area includes supplying TEOS or TMCTS to the defect area.

21. The method of claim 19 in which directing a quartz-producing precursor gas toward the defect area further comprises supplying an oxygen containing material to the defect area.

22. The method of claim 21 in which supplying an oxygen containing material includes supplying water, oxygen or hydrogen peroxide.

23. A method for repairing a opaque defect in a photolithography mask, comprising:
directing an ion beam toward an area of the mask including the defect to remove material, the ion beam incidentally implanting atoms into the mask, thereby reducing its transparency; and

directing an electron beam toward the area of the mask to remove a layer of the mask containing the implanted atoms and to increase the transparency of the area.

24. The method of claim 21 in which directing an electron beam toward the area of the mask includes directing an etchant gas toward the area of the mask.

25. The method of claim 24 in which the etchant gas comprises xenon difluoride.